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The Significance of Negative Middle Ear Pressure
and the Results of a Controlled Study of
Ventilation Tubes

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Ventilation Tubes

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Torben Haghfelt

h. a. dec.



to Lise, Peter and Bente

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Abbreviations used

- SOM = Secretory otitis media
- VT = Ventilation tube
- IN-ears = ears with intact tympanic membranes as opposed to VT-ears
- VT-ears = ears in which a VT has been inserted in the tympanic membrane as a treatment of SOM.

The present thesis was based on original articles which are marked in *References*.

CHAPTER I

A General Survey of the Problems of Negative Middle Ear Pressure and Secretory Otitis Media

SOM

The condition of secretory otitis media (SOM) has probably been known for thousands of years, as Hippocrates (460-375 B.C.) seems to indicate seasonal upper airway catarrh associated with deafness (Pahor, 1978). Throughout the 19th century, the clinical picture of SOM was described by Cooper, Politzer, Meyer, and many others (Alberti, 1974), but even today a specific definition is lacking. Many terms such as glue ear, chronic otitis media with effusion, tubotympanitis, catarrhal otitis media, and SOM are used synonymously. In 1979, a research conference discussed the definitions and the terminology associated with otitis media; it was concluded that more research information is needed to define the acute, subacute, and chronic categories of otitis media more precisely (Lim, 1980).

THE SILENT DISEASE

SOM is essentially a condition in which fluid is present behind an intact tympanic membrane, but without the clinical features of an acute inflammation. This implies that it is a silent disease in two ways: To the typical patient, a preschool child, it means a small or moderate conductive hearing loss, which is often not realized by the child. Furthermore, to the parents it also remains obscure on account of the absence of such alarm symptoms as those associated with the acute, purulent otitis media.

THE KEY TO THE CHRONIC OTITIS MEDIA SYNDROMES

SOM is a very common condition which can represent a borderline between health and disease as well as serious otological disease. In the typical case, the presence of fluid in a previously healthy middle ear is related to an upper airway infection that resolves within a few weeks. On the other hand it is supposed that advanced cases of SOM may be an omen of serious otological syndromes such as middle ear atelectasis, chronic suppurative otitis media, and chronic otitis media with keratoma (cholesteatoma) (Tos, 1981).

However, the exact link in the pathogenesis remains to be demonstrated. It is generally accepted that an abnormal middle ear ventilation is an important step in the pathophysiology of SOM as well as the chronic otitis media syndromes. Thus, along with the function of the Eustachian tube, SOM can be regarded as a key to the understanding of the development of the disabling chronic otitis media syndromes.

TYMPANOMETRY

Being a »silent disease« in children, SOM is difficult to diagnose without specific otological procedures. The development of suitable instruments for the clinical use of tympanometry has established this procedure as second to none for the measuring of middle ear pressure and the recording of the compliance of the tympanic membrane. When dealing with children, this measure has three advantages over other diagnostic procedures such as audiometry, pneumatic otoscopy, and otomicroscopy: the highest degree of objectivity, the minimal need of patient cooperation, and a high degree of sensitivity. Accordingly, tympanometry might seem to be the perfect diagnostic tool, but because of the vague distinction between health and disease, this is not the case.

PROBLEMS IN IDENTIFICATION OF SOM

The condition of SOM is preceded by a period of negative pressure in the middle ear cavity when compared with atmospheric pressure. This pressure gradient across the tympanic membrane reduces the compliance, thereby increasing the acoustic impedance of the sound transmission, with the consequence that a conductive hearing loss develops. The accumulation of fluid in the tympanum that gradually takes place reinforces the increase of the acoustic impedance, but the two different conditions cannot be separated by tympanometry alone. In order to do this an algorithm that combines tympanometry with otoscopy, audiometry, and recording of the stapedial muscle reflex must be employed. In this way, fluid behind an intact eardrum can be predicted in the majority of cases, the proportion depending on the experience of the examiner (Cantekin et al, 1980). Consequently, the difficult diagnostic process, along with the silent nature of the

disease, results in the fact that many cases are missed. This is a problem in the clinic: children can turn up with overlooked, but obvious features of longstanding disease such as language defects and middle ear atelectasis that might have been avoided with earlier treatment.

SCREENING

A screening procedure employing tympanometry might, at first sight, be a natural solution to the above mentioned problem of overlooked disease. To estimate the potential of a screening procedure, knowledge is required of the sensitivity of the method (i.e. its accuracy in identifying diseased subjects) as well as of the specificity (i.e. the accuracy in identifying non-diseased subjects). Considerable knowledge has been obtained from studies in recent years, which seems to indicate that the validity of tympanometry alone (i.e. the consistency with which positive and negative findings agree with the presence or absence of the disease) is insufficient to justify a screening of e.g. pre-school children.

INDICATIONS FOR TREATMENT OF SOM

The problems of identifying SOM is coherent with the frequent question in the daily clinic of when and how specific treatment should be instituted. Several studies, along with the present ones, have documented a high rate of spontaneous cure, for example Fiellau-Nikolajsen (1980) and Lous & Fiellau-Nikolajsen (1981). Along with the silent nature of the disease this results in a restrained attitude concerning treatment. On the other hand a hearing loss, or signs of damage to the middle ear structures, may demand intervention. It is obvious that a significant hearing loss will retard the language development after a certain period of time; this time factor, however, is not known. Nevertheless, from the daily clinic the fact emerges that in some cases of SOM the sole reason for referral may be retarded language development. The risk of permanent damage to the middle ear structures exists. Long-term observation of children that had been treated for SOM seems to indicate that when the signs of active disease have subsided, a few percent have a condition of permanent damage to the middle ear structures including a hearing loss (Tos & Poulsen, 1976, Barfoed & Rosborg, 1980).

Few studies, the present one included, indicate that the major part of the tympanic membrane changes are due to the use of ventilation tubes. However, whether the changes in the middle ear structures after 5 or 10 years are due to the tubes or to the disease process itself is not known. Nevertheless, in the clinic some primary cases of chronic otitis media may show signs of and have a history which raises suspicion of a previous SOM of that ear (Tos, 1981). So the decision of when to treat SOM is mainly based on the temperament and the experience of the individual otologist.

PRINCIPLES OF TREATMENT

Different principles are employed to obtain symptomatic or causal relief of SOM:

1. General measures:
 - a) Politzeration and/or autoinsufflation
 - b) Treatment of concurrent pathology of the upper airway such as rhinitis or allergy.
2. Medical treatment:
 - Decongestants
 - Antihistamines
 - Antibiotics
 - Corticoids.
3. Surgical principles:

	<u>Adenoidectomy</u>	<u>Myringotomy</u>	<u>Ventilation Tube</u>
1	+	—	—
2	+	+	—
3	+	+	+
4	—	+	+
5	—	+	—

In theory both Politzeration and autoinsufflation are perfect methods of treatment, but in practice only a few accomplish this.

In general the clinical efficacy of the various medications remains to be demonstrated (Fraser et al, 1977, Lildholdt et al, 1982, Lildholdt & Kortholm, 1982), despite the fact that they are widely used (Sadé, 1979). It appears as if »clinical cure« is attributed to various kinds of medicine in many of the cases where the spontaneous cure is responsible (Fraser et al, 1977). Considering the effort of generations of otologists, the lack of specific knowledge of the benefits and the side

effects of the various surgical procedures in the treatment of SOM is disappointing. This is most obvious in the question of the role of adenoidectomy as a treatment of SOM, where the results from recent investigations are divergent (Roydhouse 1980; Elverland et al, 1981).

An immediate, but temporary relief of the hearing loss is obtained by myringotomy, which seems to have negligible side-effects. The problems of the quick healing of the myringotomy incision were not solved until the re-introduction of the ventilation tube, when the use of a plastic tube was described by Armstrong in 1954. He commented: »This method is not a panacea in the management of secretory otitis media. It has been used only in chronic cases that resisted treatment«. The inherent warning was more or less overlooked during the following years, and incredible numbers of various types of »home-made« or commercially available tubes were used widespread. The general attitude seems to have been »Ubi glue — ibi tube«, and it was generally believed that the use of tubes was without side effects. However, in recent years, various long-term sequelae of the tympanic membrane have been reported; nevertheless recent publications report negligible (Sadé, 1979) or no long term complications at all, apart from few perforations (Wilson, 1981).

THE BACKGROUND OF THE PRESENT STUDIES

The present series were initiated in 1976 on the background of the »Ubi glue -ibi tube« attitude. From experience in wound healing with foreign bodies in plastic surgery, it was felt that some scarring of the tympanic membrane was inevitable. So the present study was planned with the wide scope of evaluating whether the use of the ventilation tubes in primary cases of SOM were of benefit to the patients. A controlled, prospective design was made, where patients with bilateral SOM had a tube inserted in one ear while the other ear was left intact, and the course was evaluated by frequent check-ups, (Lildholdt, 1983). During the initial course, the spontaneous variability of the middle ear status became obvious, and an epidemiological study was planned to investigate this. The original purpose was to establish an algorithm to identify SOM, based on epidemiological and clinical data. This

had to be modified as the available material revealed few patients with permanent features of SOM; other aspects of negative middle ear pressure were considered, such as the relationship to hearing loss (Lildholdt et al., 1979a), the diagnostic process (Lildholdt et al, 1980), and variations related to season and sex (Lildholdt, 1980).

CHAPTER II

Results of the present investigations

SECTION A

Studies of negative middle ear pressure

The design was based on principles of epidemiology i.e. the diagnostic discipline of community medicine, which undertakes the examination of whole populations. The population of this study comprised 352 children, aged 6.5 to 7.5 years, taken from 16 classes of the second grade of school.

These classes were selected from 6 schools to ensure a representative distribution of the social groups of the community, but apart from this, further selection of the material was avoided. The typical patient with SOM is a pre-school child, but the second-graders were employed for various reasons. Pure tone audiometry is important in the estimation of this condition, and the reliability of this test procedure is improved in the older children. In order to avoid selection, the first grade — which is not obligatory — was not employed. The organisation of the study was facilitated by cooperation with the school authorities.

A screening procedure was carried out 5 times in the course of one year, whereby middle ear pressure and screening audiogram at 20 dB were recorded. On each occasion a questionnaire was answered by the parents. The children who failed this screening according to fixed criteria had a full pure tone audiogram, and the middle ear pressure was measured every month. Only 5 children (1.4 %) were found to have a permanent bilateral hearing loss of more than 20 dB, and they were dismissed from the study.

The diagnosis of negative middle ear pressure in children, (Lildholdt et al, 1980): An estimate of the

accuracy of symptoms and signs in the diagnosis of negative middle ear pressure was calculated from the available data. From the questionnaires, information was obtained on upper respiratory tract infection, oppression in the ears, and hearing ability, and this was recorded as symptoms. Corresponding to this, the results of otoscopy and screening audiometry were recorded as signs. The middle ear pressure at the time of the testing was used as a reference in the calculation of the sensitivity and the specificity of each parameter. In order to make a comparison between the two, a unified measure of the clinical validity was necessary, and the »*relative liability*« was calculated.

The symptoms and signs investigated were relevant in that they were statistically significantly associated with the occurrence of negative middle ear pressure; however, the estimates of the sensitivities were not acceptable. The screening audiogram showed the highest clinical validity, but from a clinical point of view, the most conspicuous finding was the insufficiency of otoscopy in this diagnosis — in fact it corresponded to a yes/no guess. This is important because otoscopy is traditionally the primary step in the diagnosis of middle ear pathology to non-otologists. In general the conclusion was that tympanometry is an absolutely necessary tool in the diagnosis of negative middle ear pressure. Recently this was confirmed by Holmberg et al (1981). However, this type of investigation is the result of a theoretical dissection of a complex of factors that are considered together in the clinic. The inherent simplifications may lead to errors which might be avoided by appropriate use of computer multivariate analysis, but so far this has not been described in this field. Until it is, the present types of analysis can be useful guidelines to the individual clinician in the diagnostic procedure.

After the publication of the paper an error has been shown in Table I, where the conditions of the chi-square test are not fulfilled. It concerns »oppression in the ears« and accordingly the chi-square test cannot be used.

Variations by season and sex. (Lildholdt, 1980). This was investigated in order to evaluate any possible predictive value or threshold of pathology of negative middle ear pressure related to SOM. The year of the testing

was split into 5 periods, and by stratifying the range of pressure into 4 categories, a distinct seasonal pattern of occurrence was found. The low-negative pressures were prevalent during summer-autumn, while the high-negative pressures were most frequently found during late winter. There is a flaw in the results due to the fact that screenings were not performed during the vacations in mid-June and July, and that the frequency of the screenings varied in general. Sex-related differences were found, in that boys suffered from bilateral high-negative pressures more frequently or for longer periods. The cumulated incidences of various categories of negative pressure revealed such large figures that the term pathology could hardly be applied in any of the categories. Furthermore, the figures probably understate the true incidence as they represent a few single examples in a continuously varying parameter. Consequently, tympanometry would overestimate the incidence of pathology in a population of children in the sense that the predictive value of single measurements would be characterized by a high sensitivity but a very low specificity, thereby opposing screening procedures.

The correlation between negative middle ear pressure and the corresponding conductive hearing loss, (Lildholdt et al, 1979a). The large number of measurements made possible an investigation of this relationship that had previously not been made on the basis of clinical material. It was found that the inter-individual (= »between children«) variation was wide, which is consistent with clinical experience. The mean of the intra-individual (= »within-child«) variation in hearing loss owing to various middle ear pressures revealed a straight line, characteristic of each frequency tested. On the basis of the inter-individual variation, it was concluded that a middle ear pressure worse than -150 mm H₂O should be considered a probable hearing handicap. That this value represented the current threshold of pathology at that time, concerning SOM, (Renvall et al, 1975) was opposed by other findings from the present study.

A comparison of the main results of this study with corresponding reports of other investigations

This study of negative middle ear pressure opposed

some statements found in the literature. In 1974, Harker and Van Wagoner, and in 1975, Renvall et al described tympanometric assessment of the middle ear status by single measurements. They utilized single measurements in contrast to the repeated tests of this study that demonstrated vast variations from time to time. The cumulated incidences of categories of pressures worse than -150 mm H₂O contradicted the fixed threshold of pathology posed by Renvall, (Renvall, 1975, 1980) and others. The review by Lamb & Dunchel (1976) probably represents the current recommendation of screening procedures at that time, and the main result of the present study was to question this.

Another study of negative middle ear pressure and SOM, which is comparable to the present study in many respects, was conducted about a year later by Lous & Fiellau-Nikolajsen, (1981). They examined a group of 387 seven-year-old pupils using an automatic instrument which detected only impedance minimums in the range between $+200$ mm H₂O and -300 mm H₂O. Moreover, they applied a different stratification of the results: tympanogram type A > -100 mm H₂O, type C: ≤ -100 mm H₂O and type B: no minimum and absence of the acoustic reflex. As they were primarily interested in type B tympanograms, they included fewer details regarding the A-C interval in their analysis as compared with the 4 or 5 levels of the present study. In the discussion of their results, they made an estimate to compare with the cumulated incidences of the present study, and agreement was found. Correspondingly, they confirmed the dynamic features of middle ear pressure including the seasonal variations, warning against treatment based on single measurements. However, this comparison emphasized the confusion that is added to the problems on account of differences in equipment and measures employed.

CONCLUSIONS

The discussion about impedance screening is still going on; in general its supporters stick to the arguments developed some 10 years ago as presented by Northern (1980), while opposers share the view of Paradise & Smith (1979) that more research is needed before screening programs are justified.

In general, the measurement of middle ear pressure alone is of little value as a predictor of SOM.

SECTION B

THE STUDY OF VENTILATION TUBES IN SOM (Lildholdt, 1983)

This study attempted to find out whether the use of the ventilation tubes (VT) in primary cases of SOM was of benefit to the patients or not. At the time of the initiation of the study, adenoidectomy was considered to be an important part of the treatment of SOM, and for various reasons it was decided to perform adenoidectomy on the whole material.

Conditions of eligibility for entry into the study were that a VT should not have been used previously («primary cases»), a middle ear pressure ≤ -150 mm H₂O on both sides, and a difference in middle ear pressure ≤ 100 mm H₂O. If an audiogram could be made, a difference ≤ 15 dB between the ears was accepted. Randomization was achieved by treating the right ear of patients born on even dates and the left ear of patients born on odd dates. Entry into the study required that the myringotomy of the appropriate ear showed fluid; if that middle ear was dry, the patient was excluded from the study, irrespective of the contents of the other ear.

The check-ups were done at 3 weeks and 3 months postoperatively, then at 3 monthly intervals, but after the extrusion of the VT at 6 monthly intervals. If complications arose, the patients were seen more frequently and a total of 1700 examinations were performed on the 150 children who made up the material of the study.

The results of this study consist of a description of the average course in the two types of ears, the complications encountered, the sequelae that appeared, various estimates of the final results, and based on these, an investigation into possible predictive factors of the course of the SOM.

The average course. This was described by comparing the data from the tympanometry and the audiometry of the treated ears (VT-ears) with that of the intact ears (IN-ears). Preoperatively, the two types of ears were

alike: the mean hearing loss of both types of ear was about 23 dB, and about 68 % showed flat tympanograms. Three weeks postoperatively, the IN-ears showed about half the proportion of flat tympanograms, and the corresponding mean hearing losses differed: VT-ears = 10 dB, IN-ears = 17 dB. This changed at the 3-months check-up in that the differences between the ears were now insignificant and this proved to be the case throughout the period of observation.

The period of observation revealed important individual variations in middle ear pressure and hearing loss. At one extreme there were signs of fluid on both types of ears. Thus, in 16.5 % of the VT-ears two or more VT's were placed according to the rules of the study. The increased incidence of atrophy of the tympanic membranes in this subgroup of the VT-ears will be discussed later. At the other extreme, 50 % of the IN-ears that showed a normal tympanogram at the 3 months' check-up, indicated rapid improvement. On an average this was a permanent characteristic in that half the tympanograms of both types of ears proved to be of that category at the one-year check-up, and remained so throughout the period of observation. Unfortunately, an appropriate way of displaying both the fluctuations of individual ears and of individual subjects between these categories was not found.

Complications encountered. VT-ears showed a *discharge* in a total of 30 % of the ears, and from a prognostic point of view two categories emerge. Postoperative suppuration, which was diagnosed within 8 weeks, was found in 8 % of the ears. The statistical analysis revealed that this was not associated with late changes of the eardrums. Drainage later than this interval was found in 22 % of the ears, and these ears showed an increased incidence of tympanosclerosis as discussed later.

16 cases *granulation tissue* developed around the VT, and in all these cases the VT was removed; in 5 cases sequelae developed.

After the spontaneous extrusion of the tubes, *permanent perforations* or *keratoma* (cholesteatoma) were not seen; in one case the tube was removed having been in place for 3 years and a hole persisted, required a myringoplasty.

In the cases of the IN-ears there were quite often recurring complaints of *pain*, typically few hours after going to bed, and a dose of acetylsalicylic acid usually solved the problem. The prevalence of pain was not recorded for various reasons, mainly the great variations in the pain thresholds of the children and the attitudes of the parents. Very few developed acute otitis media, and no complications occurred. *Persisting signs of SOM* was the greatest problem encountered of the IN-ears, due to the ethical aspects of omitting the treatment with a VT. In 8 % a VT was used in IN-ears either because of suspected language retardation or because of the condition of the ear.

Sequelae of the TM's. The routine of the check-ups was expanded at the end of the study; so that speech audiometry, an automatically plotted tympanogram, and otomicroscopy with a pneumatic otoscope, were obtained for most of the children.

In an early phase of the study (Lildholdt, 1979) it became obvious that in many of the VT-ears, various kinds of *cicatricial changes* developed in the tympanic membranes. Much effort was devoted to obtaining a »semi-objective« measure of this, but ultimately a relatively simple score system was used, estimating 3 qualities of the tympanic membrane: flaccidal retraction, tympanosclerosis, and atrophy of the tensa. This was further quantitated by a score of 0-3, where the normal appearance was given score 0 and the most advanced pathology was given score 3.

The comparison of the VT-ears with the IN-ears revealed that the various degrees of flaccidal retraction were equally distributed in the two groups, and of those about 67 % were normal; flaccidal retraction was associated with a lower middle ear pressure.

In contrast to these equal findings, tympanosclerosis of the pars tensa occurred in 52 % of the VT-ears, compared with 11 % of the IN-ears. Corresponding to this atrophy was found in 66 % of the VT-ears, compared with 14 % of the IN-ears. However, these changes of the pars tensa could be present either in isolation or in combination. In the further analysis of this, the scores of 0 and 1 (= changes localized solely at the previous site of VT) were combined and classified as »normal«, while the scores of 2 and 3 were »pathological«. This analysis revealed that the occur-

rence of atrophy was related to the number of VT's inserted. Tympanosclerosis showed the same tendency but with less statistical evidence. A similar relationship was found between the occurrence of tympanosclerosis and a discharge from the VT-ear that occurred later than 2 months postoperatively, whereas atrophy was not related at all.

Furthermore, an estimate was made of the cumulated incidences of the various categories of the tympanometry of each ear. It was found that in ears with atrophy, the prevalence of the »normal« category (0 to -150 mm H₂O) was lower, and the »pathological« category (-400 mm H₂O or flat) was higher ($p < 0.01$). This also applied to tympanosclerosis, but with weaker statistical evidence ($0 < 0.1$).

In order to make the assessment of these tympanic membrane abnormalities objective, the impact on the hearing sense was assessed. A subgroup of children was selected, all had comparable ears apart from the fact that the VT-ears showed »pathology«, atrophy and/or tympanosclerosis (score 2-3), while the IN-ears were »normal« (score 0-1). By applying a statistical test that compares the two ears of each child (Wilcoxon Sign Rank Test), a difference in the results of the speech audiometry in favour of the IN-ears appeared ($p = 0.03$, two tailed). However, the mean differences as regards the hearing loss constituted only a few dB.

The »final« results. The sequelae of the eardrums are one aspect of the »final« results, but a more general estimate would be useful. On the basis of middle ear pressure, hearing level, and otomicroscopy, each ear was described as either »normal«, »pathological« or »mixed«. Similarly, each child was categorized by adopting the description of the most diseased ear of that child. The group of »pathological« ears contained both VT-ears and IN-ears. Of the VT-ears 27.6 % were »pathological« and of the IN-ears 12.7 % were »pathological«; this difference was statistically significant ($p < 0.001$). Correspondingly the condition of 31.3 % of the children was rated »pathological«, but in only 9 % did this apply to both ears.

Possible predictive factors concerning the course of SOM. The score system of each ear and of each child

made a comparison between preoperative data and final results possible. In each of the following parameters it was found that $p > 0.1$: with regard to quantity and quality of the middle ear fluid, the symptoms and signs of adenoids, and the ABO blood group system. The later insertion of a contralateral VT predicted a worse final result ($p < 0.005$). Tonsillectomy performed at the primary operation seemed to predict a worse »final« result, but the relationship was very complex. The occurrence of tensa atrophy and tympanosclerosis was higher among children that had had their tonsils removed ($p < 0.001-0.04$).

DISCUSSION

The wish of the researcher to solve all problems in one study was inconsistent with the common place aspect of what actually could be accomplished. Consequently, some aspects of these extremes should be discussed.

There is a fallacy inherent in the basic idea of the study i.e. that the presence of fluid had to be registered in both ears, which is inconsistent with the condition that one of the tympanic membranes had to remain intact. Consequently, the presence of fluid in the intact ear can only be ascertained indirectly, which means with less reliability. This introduces a minor skewness of the material, because the patients that were eligible for the study were only included if fluid was present in the ear to be treated; a small proportion of the corresponding intact ears probably had a negative pressure but without fluid. If the reverse was true i.e. no fluid in the ear to be treated but fluid present in the ear to be intact, the patient would not be included in the study. Accordingly, the design of the study »tends to put a VT in the worse ear«, but the preoperative data of tympanometry and audiometry indicate that the error is of minimal importance.

Another flaw concerns the homogeneity of the material. Since the present study was initiated, epidemiological studies of negative middle ear pressure (Lildholdt 1980, Lous & Fiellau-Nikolajsen 1981) have shown the state of the middle ear to be far more dynamic than previously known. According to this, a more strict selection of patients for this study would have been appropriate, e.g. by eliminating the patients who did not reveal constant features of SOM during a

certain period of observation. This would reduce the number of patients eligible for the study, but the main reason for maintaining the original design was the scope of imitating the daily clinic, where a VT was used whenever SOM was diagnosed.

The description of the high incidence of sequelae to the VT's is probably the main result of this study, along with the detection of the multifactorial pathogenesis where infection, high-negative middle ear pressure, and a probable influence related to the tonsils are involved. Little is known about the long term consequences of the sequelae of the eardrums. Apart from the minimal hearing loss these abnormalities represent a weakening of the mechanic characteristics of the eardrum. Probably this means that a perforation may result from a trauma that a normal membrane would resist, for example a barotrauma. The risk of chronic otitis media without or with cholesteatoma was discussed by Tos (1981).

The description of the otomicroscopic appearance of the tympanic membrane is highly subjective, which involves a risk of biased results; however, the rates of the various changes found in the VT-ears have been reported by others (Mawson & Fagan, 1972; Tos & Poulsen, 1976 and Barfoed & Rosborg, 1980).

Ideally the children might have been randomized into groups of plus or minus adenoidectomy along with the current design. Though at present a study has not evolved which has solved the basic problem of randomization i.e. to desist from adenoidectomy in cases with heavy symptoms and signs. So again the solution was to imitate the daily clinic and perform adenoidectomy in all children with SOM (Kokko, 1974; Tos & Poulsen, 1976). The immediate impression from the course of the IN-ears showing rapid postoperative improvement of tympanograms and hearing loss, might be that adenoidectomy had some beneficial effect, but considering the high rate of spontaneous cure, this may be erroneous. This was shown by means of a screening study in which the group of children who developed a flat tympanogram was followed. About 70 % resolved within the first month and about 80 % had disappeared within 3 months (Lous & Fiellau-Nikolajsen, 1981). This change seems to be slightly more rapid than in the present analysis, but the material is different from that of the

present study. It seems probable that a population of children with SOM, diagnosed by means of a screening procedure, is different from the present adenoidectomized population consisting of hospital patients admitted according to a waiting list which could vary from a few weeks to a few months. However, it is possible, that adenoidectomy has a certain contributing therapeutic effect; this was also indicated by the study of Elverland et al (1981).

From the present material of primary cases of SOM, the long term average hearing gain that is obtained by employing a VT is minimal, and it seems to be associated with a high rate of complications and sequelae. Therefore the question of whether the VT should be used at all in this group of patients is a matter for discussion, but unfortunately the influence of the type of hearing loss in question is unknown (Paradise, 1981). In the epidemiological study by Lous & Fiellau-Nikolajsen (1981), the pupils were tested by means of a phonological test, SITO = sentence repeating test, when they started school; one year later, OS 400 = a silent reading word test, was performed. Prospective data from tympanometric and audiometric screening was obtained between the two phonological tests. Both tests revealed differences related to sex and social group, but no difference could be related to the condition of the middle ear (Lous, 1981).

The nihilistic point of view may be claimed that SOM is nature's own defence against possible hazards of alternating and/or prolonged negative middle ear pressures, and that the fluid will be drained in the natural way when the Eustachian tube function returns to normal. This seems to involve about 75 % of the children in the present study, but still a »heavy« group remains who suffer from recurring SOM each time the VT is extruded, and this seems to apply particularly to the patients with cleft palate (Sadé, 1979). In this »heavy« group a VT should probably be kept functioning for years, but the basic problem of predicting this outcome at the primary stage is still unsolved.

A comparison of the main results of this study with other investigations

Until lately it has not been possible to decide whether the reported late sequelae of the tympanic membranes

were due to the VT's, or were a result of the disease process itself. A number of retrospective studies have confirmed the rate of sequelae found in this study. Mawson & Fagan (1972) reported an abnormal appearance of 60 % of 202 ears treated with VT's, but their analysis did not reveal any close correlation to poor hearing. Apparently they did not compare the hearing level related to the 40 % of the eardrums with normal appearance with those of various degrees of abnormality. The mean period of observation was about 2 years. They noted that the frequency of sequelae increased with the length of the period of observation, but the follow-up rate was not specified. Tos & Poulsen (1976) reported late results in 184 ears in their comparison of the condition of ears one-to-five years postoperatively with that of five-to-eight years postoperatively. The frequency of tympanosclerosis seemed to have increased with time and in only 44 % of the ears were the tympanic membranes classified as normal. They found a connection between atrophy and reinsertion of grommets. Apparently the sequelae did not affect hearing. The follow-up rate was not clearly specified, but more than 30 % seemed to have dropped out. Barfoed & Rosborg (1981) reexamined 173 ears some six years after the primary treatment, and only 12 % had dropped out. During the functioning of the VT 34 % of the ears suppurated. Only 21 % of the tympanic membranes were classified as normal, 61 % showed various degrees of tympanosclerosis, and in general 55 % showed widespread changes of the tympanic membrane. A difference in hearing between normal eardrums and those with widespread changes in favour of the normal ($p < 0.05$) was found.

Only one study has been found in the literature that was comparable to the present investigation. Brown et al (1978) reported a 5 years' follow-up of 55 children with bilateral SOM who had a tube in one ear while the other was left intact, and adenoidectomy was performed in all cases. The follow-up was carried out at three-monthly intervals for the first year and then reviewed five years later. The material consisted of children aged between 4 and 10 years, thus excluding approximately half of the material of the daily clinic. The criteria for entry were not specified, and tympanometry was not used at all. The procedure of randomiza-

tion was not specified and may be weak, as the mean hearing loss of the VT-ears was 25 dB compared to 23 dB of the IN- ears. The tympanic membranes were evaluated without the otomicroscope. Despite its weak points, the study of Brown et al confirms the course of the hearing loss during the first year of observation in the two types of ears, that was found in the present study. Most important, it confirms the difference in the occurrence of sequelae of the two types of ears, reporting tympanosclerosis and scars in 55 % of the VT-ears and in none of the IN-ears (assessed without the otomicroscope). Finally the mean hearing level at the five year follow-up was about 13.5 dB in the IN-ears compared to 17.5 dB in the VT-ears; a possible relationship to the eardrum sequelae was not discussed. Middle ear pressure was equal in the two types of ears but the statistical level of significance was not indicated; the follow-up rate was not mentioned.

Summary of discussion

1. In general, the use of VT's is not justified in primary cases of SOM. If these are observed for several months only a small proportion of them will require surgical treatment of the middle ear.
2. If a VT is considered in the treatment of SOM, it should be taken into account that there is a high probability of complications such as suppuration and the later development of sequelae of the tympanic membrane. Ultimately there is a risk of permanent impairment of the middle ear function.

CHAPTER III

General conclusions

The results of the present investigations point towards a nihilistic attitude in SOM. The various categories of negative middle ear pressure are too variable to possess predictive value and no such predictor has been found. If manifest SOM is present, the spontaneous cure seems at present to be the best »treatment« in the majority of the cases, but still a »heavy« group remains with unsatisfactory results. The VT's solve the immediate problems in this group, but the sequelae throughout

the remainder of life seem ominous, although the interplay of disease and treatment is unknown.

These results call for more research in all aspects of SOM and it is to be hoped that preventive measures will evolve, along with principles of treatment involving less serious side-effects.

Some suggestions for future research

1. A prerequisite for preventive measures and better methods of treatment in SOM is a detailed knowledge of the *epidemiology*, the *natural history* including the long-term implications, the underlying *pathophysiology*, and the *pathogenesis* of the various processes taking place in the development of SOM.
2. An area which reveals a most striking lack of knowledge is that concerning *methods for clinical use, of measuring the quality and quantity of the underlying Eustachian tube dysfunction* in SOM. Such measures might contribute to establishing algorithms to predict the outcome in individual cases of SOM, and thus serve as a guideline in the clinic. The available methods have disadvantages that impede clinical use, for example the fact that the pressure chamber demands extensive resources, the various inflation — deflation techniques (Lildholdt et al, 1982) are unphysiological, requiring a perforation of the tympanic membrane. The principle of sonotubometry (Virtanen, 1978; Murti et al, 1980) seems to be ideal as a method for clinical use; however, so far the technical problems have not been solved and much effort should be devoted to this problem.
3. *Investigation of the pathological processes that cause the sequelae of the VT's.* These processes are hardly known, but the role of immunology in the pathogenesis of tympanosclerosis has recently been demonstrated in the guinea pig tympanic membrane in some outstanding experiments by Poliquin et al (1980). Further research may have implications in the search for VT's that are better tolerated by the tissues, and also for the important questions of otology such as keratoma and chronic otitis.
4. *Research in non-invasive methods of treatment* especially medical treatment. Ethical aspects prevent the use of systemic steroids that have been reported

to be effective in a small series of cases (Schwartz et al, 1980), and the local application seems inefficient (Lildholdt & Kortholm, 1982). In recent years the non-steroid, antiinflammatory drugs that are prostaglandine — inhibitors have been shown to have negligible side effects. Increased contents of prostaglandines have been demonstrated in the effusion of SOM in chinchillas (Jung et al, 1980) and clinical trials employing prostaglandine — inhibitors seem indicated.

CHAPTER IV

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CHAPTER V

Summary in Danish

Dansk resumé

SEKRETORISK OTITIS MEDIA

Betydningen af negativt mellemøretryk og resultater fra en kontrolleret undersøgelse af tubulationsrør.

KAPITEL I

Oversigt over problemerne ved negativt mellemøretryk og sekretorisk otitis (SOM)

Sekretorisk otitis media (SOM) har sandsynligvis været kendt i årtusinder, men er først beskrevet i forrige århundrede, uden at der dog i dag kan opstilles en præcis definition. SOM betegner en tilstand, hvor der findes væske bag en intakt trommehinde, men uden tegn på akut betændelse. Dette medfører af to årsager, at det er en sygdom, som ikke bemærkes: dels af patienten i form af et høretab, men også af omgivelserne, fordi der ikke findes ledsagende symptomer f.eks. smerte eller feber. Som følge heraf er diagnosticering af tilstanden problematisk, men dette skyldes også andre vanskeligheder. F. eks. kan mellemøretrykmåling (tympanometri) ikke sikkert afgøre, om der er tale om et forstadie i form af udtalt undertryk, eller der foreligger SOM med væske. Disse forhold manifesterer sig i klinikken ved at fremskredne tilfælde findes på et tidspunkt, hvor man må formode, at en tidligere erkendelse af tilstanden ville have afværget følgevirkninger f. eks. sprogproblemer på grund af høretabet eller skader på mellemørets strukturer specielt trommehinde og høreknogler. Umiddelbart synes screeningsundersøgelser med tympanometri at være løsningen, men erfaring fra de senere år viser, at dette ikke er tilfældet.

Usikkerheden omkring SOM gælder også spørgsmålet om, hvornår og hvordan behandlingen skal iværksættes. På den ene side er der en betydelig spontan helbredelse, og på den anden side er der risiko for varige følger i form af forandringer i mellemøret med eller uden høretab. Det må konstateres, at beslutning om behandling i høj grad er baseret på den individuelle otologs temperament og erfaring. Yderligere er den specifikke viden om fordele og ulemper ved de forskellige behandlingsprincipper stærkt begrænset. Den kirurgiske behandling med isætning af et trisseformet tubulationssør af plastik i et snit i trommehinden blev introduceret i 1954 og har i de senere år fundet udstrakt anvendelse. Imidlertid er der fremkommet meddelelser om langtidsfølger for trommehinderne efter denne behandling.

På denne baggrund startedes i 1976 en undersøgelse for at vurdere, om tubulationsrørene var en fordel for patienterne ved behandlingen af primære tilfælde. Det viste sig hurtigt, at mellemørets status (spec. mellemøretryk) varierede betydeligt, hvilket svækkede kriterier-

ne for optagelse i undersøgelsen. Derfor startedes en yderligere undersøgelsesserie for at afklare betydningen af negativt mellemøretryk.

KAPITEL II

Resultater af undersøgelserne

Negativt mellemøretryk. Der blev i et skoleår udført gentagne undersøgelser af mellemøretryk og hørelse på den samme gruppe af 352 skolebørn i alderen 6 til 7 år. Samtidig besvarede forældrene spørgeskemaer om barnets tilstand. Ved at sammenligne symptomer såsom forkølelse, trykken for ørerne og hørelse samt resultater fra otoscopi (iagttagelse af trommehinden) og screening audimetri (høreprøve) med resultater af den præcise måling af mellemøretrykket, blev det klart, at screening audiometri havde den bedste kliniske pålidelighed. Mest overraskende var det, at værdien af otoscopi, som traditionelt er første skridt i diagnosen af mellemøresygdom for ikke specialister, svarede til gætteri: ja/nej. Det konkluderedes, at tympanometri er absolut nødvendig i diagnosen af negativt mellemøretryk. Ved hjælp af de gentagne målinger fandtes betydelige variationer i forekomsten af negativt mellemøretryk i relation til sæson og køn. De mest udtalte undertryk fandtes i den sene vinter, og drenge havde udtalt undertryk hyppigere eller i længere perioder. Det konkluderedes, at variationerne i negativt mellemøretryk begrænser denne parameters værdi som tegn på SOM. De gentagne målinger af hørelse blev sammenlignet med tilsvarende målinger af mellemøretryk, og ved statistisk analyse fandtes en retlinet sammenhæng. Den praktiske værdi heraf begrænses af store individuelle variationer, men det konkluderedes, at et mellemøretryk lavere end -150 mm H₂O udgør et muligt hørehandicap.

Behandling af SOM med tubulationsrør. For at vurdere værdien af denne behandling udvalgte blandt børn, som blev indlagt i afdelingen, primære tilfælde af SOM i henhold til visse opstillede kriterier. Når disse var opfyldte, blev der foretaget et snit i trommehinden på højre øre på børn født på lige datoer og på venstre øre på børn født på ulige datoer. Hvis der fandtes væske i

det pågældende øre, blev der isat et tubulationsrør, og patienten indgik i undersøgelsen, idet den modsatte trommehinde forblev intakt. Hvis øret var luftfyldt, blev patienten udelukket uanset forholdene i det modsatte øre. Alle børn i materialet fik fjernet polypper og 34 % mandler på grund af gentagne tilfælde af halsbetændelse. Første kontrol var 3 uger efter operationen og herefter hver 3. måned, dog hver 6. måned efter udstødelsen af røret. Der blev foretaget 1.700 konsultationer som led i den vedvarende undersøgelse af de 150 børn i det omhandlede materiale.

Det gennemsnitlige forløb i de 2 ører blev beskrevet ved mellemøretrykmåling og høreprøver. Bortset fra de første par måneder efter operationen var det gennemsnitlige forløb ens i de 2 typer ører, omend med betydelige individuelle variationer. I forløbet fandtes betændelsesflod fra det tubulerede øre hos 30 %, og hos de 22 %, som flød senere end 2 måneder efter operationen, fandtes en betydelig højere forekomst af tympanosclerose (forkalkning i trommehinden). Hos 8 % af de primært intakte trommehinder blev der senere isat tubulationsrør af forskellige grunde. Efter at undersøgelsen havde forløbet i 5 år, blev der udført en udvidet kontrolundersøgelse. Ved analysen af resultaterne heraf, fandtes en betydelig større forekomst af tympanosclerose (forkalkning) og atrofi (vævssvind) i trommehinder, der tidligere havde været behandlet, sammenlignet med forholdene i de intakte ører. Endvidere var atrofi mest udtalt i ører, hvor mere end ét tubulationsrør havde været anvendt, og i ører hvor der oftest var målt et stort undertryk. Disse forandringer medførte en dårligere hørelse, omend forskellen næppe er af praktisk betydning. På grundlag af resultaterne af mellemøretrykmåling, høreprøver og undersøgelse af ørerne med mikroskop blev hvert øre karakteriseret som enten »normalt«, »patologisk« eller »blandet«. Af de tidligere behandlede ører fandtes 28 % »patologiske«, medens dette gjaldt 13 % af de intakte ører. Tilsvarende blev ørernes tilstand betegnet som »patologisk« hos 31 % af børnene, men kun hos 9 % var dette tilfældet i begge ører. Dette karaktersystem blev anvendt til at undersøge, om nogle af de oplysninger, som forelå før eller ved operationen, kunne forudsige forløbet af SOM. Det viste sig, at den gruppe af børnene, hvor mandlerne var fjernet, havde et dårligere

slutresultat angående ørerne, sammenlignet med gruppen med intakte mandler.

KAPITEL III

Generelle konklusioner.

Resultaterne fra disse undersøgelser peger i retning af en nihilistisk holdning overfor SOM. Negativt mellemøretryk varierer så udtalt, at denne parameter ikke har nogen værdi til at forudsige SOM, og dette gælder også de øvrige undersøgte parametre. Hvis SOM findes, synes naturen at være bedst til at helbrede tilstanden hos flertallet af børnene, men stadig bliver der en »tung« gruppe tilbage med utilfredsstillende slutresultat. Tubulationsrørerne løser de øjeblikkelige problemer hos denne gruppe, men senfølgerne i trommehinderne synes at være ildevarslede, endskønt samspillet mellem sygdom og behandling ikke er afklaret. Derfor er yderligere forskning nødvendig på alle områder vedrørende SOM, og forhåbentlig kan der udvikles forebyggende foranstaltninger sammen med behandlingsprincipper med færre bivirkninger.

